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MATHEMATICS

ON FRACTIONAL TERMS OF POLYNOMIALS AND OF OTHER FUNCTIONS

By I. VINOGRADOW, Member of the Academy

In one of my recent papers (1) I used an entirely new method in discussing the problem of the possibility of approximation to numbers having a given fractional term β by the values of the function

$$f(x) = \alpha x^n$$

of an integral argument x. It appears that this method can easily be generalized to include the polynomials of the most general kind

$$f(x) = \alpha x^n + \alpha_1 x^{n-1} + \ldots + \alpha_n$$

with real coefficients. To the case of such polynomials may be reduced the case of more general functions, which are in a certain sense well apporximated by polynomials.

Here I shall only quote the principal of the theorems proved by me. A full account of the results obtained will be found elsewhere.

Theorem 1. Let n be a constant integer $\geqslant 20$,

$$\nu = \frac{1}{n}; \quad f(x) = \alpha x^n + \alpha_1 x^{n-1} + \ldots + \alpha_n,$$

where α, α_1, $\ldots$, α_n are real, while

$$\alpha = \frac{a}{q} + \frac{\theta}{q^2}; \quad (a, q) = 1; \quad q > 0; \quad |\theta| \leqslant 1.$$

Such a constant C can then be found that, whatever the real β, the system of inequalities

$$|f(x) - m - \beta| < Cq^{-\delta}; \quad \delta = \frac{\nu^3}{5 \lg^2 4n}$$
$$0 < x \leqslant q^{2\nu}$$

may be satisfied by the integers x and m.

Theorem 2. Let it be assumed that in the interval (P, Q), the real function $f(x)$ has an $n^{\text{-th}}$ and an $(n+1)^{\text{-th}}$ derivative and that

$$\frac{1}{A} \leqslant f^{(n)}(x) \leqslant \frac{k}{A}; \quad |f^{(n+1)}(x)| \leqslant \frac{l}{A^2},$$
$$Q - P \geqslant rA^{2\nu},$$

where $A \geqslant 1$ and k, l, r are positive constants. Such a constant C may then be found that, whatever the real β, the system of inequalities

$$|f(x) - m - \beta| < CA^{-\delta},$$
$$0 < x \leqslant A^{2\nu}$$

can de satisfied dy the integers x and m.

Possibilty of other results. The above results may be further improved. The same method may be applied to other similar problems, e. g. to the problem of simultaneous approximation of numbers $\beta_1, \ldots, \beta_r$ by numbers

$$f_1(x) - m_1,$$
$$f_2(x) - m_2,$$
$$\ldots\ldots$$
$$f_r(x) - m_r,$$

where x, $m_1 \ldots m_r$ are integers.

The estimates obtained for all these problems are infinitely better than those obtained for similar problems by the Weil method.

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HYDRODYNAMICS

STREAMLINING OF GAS-FILLED ENVELOPE BY FLAT STREAM OF IDEAL FLUID

By N. SLĬOZKIN

(Communicated by S. Chapligin, Member of the Academy, 10. IV. 1935)

Let it be assumed that a gas-filled envelope in the shape of an infinitely long fixed cylinder has been immersed in an illimitable ideal fluid having at infinity a velocity equal to q_0, parallel to the axis x. In order to ensure the stability of the shape of the envelope, the inner pressure of the gas must exceed the outer pressure. Since the outer pressure is variable at the outline, the shape of the envelope will differ from the circular and is to be found, this being the problem to be solved.

The motion is taken to be flat and steady. At the boundary of the envelope, the difference of pressure is balanced by the normal component of the tension forces of the envelope. This normal component is proportional to curvature; if, therefore, C is the constant of Bernulli's integral, P_1 the constant pressure within the envelope, μ the coefficient of proportionality, ρ density, then, assuming

$$\frac{P_1 - C}{\mu} = a; \quad \frac{\rho}{2\mu} = b,$$

the boundary condition may be written as follows:

$$a + bq^2 = \frac{1}{R}. \tag{1}$$

We assume:

$$z = x + iy, \frac{dw}{dz} = u - iv = q_0 e^{-i\omega}, \ \omega = \Theta + i\tau, \ w = \varphi + i\psi,$$

the boundary condition (1) will then have the form:

$$\frac{d\Theta}{d\varphi} = \pm\left(\frac{a}{q_0} e^{-\tau} + b q_0 e^{\tau}\right). \tag{2}$$

Let us suppose that the envelope has two axes of symmetry. Let an area in the plane w be figured on the outside of a circle of a unit radius of a plane of a variable $\zeta = \xi + i\eta$.

For the new area under consideration the boundary condition may be written as follows:

$$\frac{d\Theta}{d\alpha} = \pm \varphi_0 \sin\alpha \left(\frac{a}{q_0} e^{-\tau} + b q_0 e^{\tau}\right). \tag{3}$$

The function $\omega = \Theta + i\tau$ in the plane ζ is regular throughout outside the circle, while on the circle its real portion suffers a break at points $\zeta = \pm 1$, whereas its virtual portion is at these points converted into infinity; this function may therefore be written thus:

$$\omega(\xi) = i \log \frac{\xi^2 - 1}{2\zeta^2} + \Omega(\zeta), \tag{4}$$

where $\Omega(\zeta)$ is regular both outside and on the circle. With this assumption and supposing $\Omega(\zeta) = \Theta + iT$, we have, from (3)

$$\frac{d\Theta}{d\alpha} + 1 = -2\pi\lambda\left[\sin^2\alpha e^{T(\alpha)} + ke^{-T(\alpha)}\right], \tag{5}$$

where $\lambda = \pm 2\pi b q_0 \varphi_0$, $k = \frac{a}{bq_0^2}$ are both undimensional values.

Making use of Dini's ratio

$$T(\beta) = -\frac{1}{2\pi}\int_{-\pi}^{+\pi} \Theta' \log\left(4\sin^2\frac{\alpha-\beta}{2}\right) d\alpha, \tag{6}$$

as well as of the fact that $T(\pi - \beta) = T(\beta)$, we obtain from (5) and (6) an integral equation for determining $T(\beta)$:

$$T(\beta) = \lambda\int_0^{\pi} \left[\sin^2\alpha e^{T(\alpha)} + ke^{-T(\alpha)}\right] \log\left[4\sin^2(\alpha-\beta)\right] d\alpha, \tag{7}$$

where $\lambda = -2\pi b q_0 \varphi_0$.

The integral equation (7) is solved by the method of succesive approximations. The first three approximations have the form:

$$\begin{aligned} T_1(\beta) &= \frac{\lambda\pi}{2}\cos 2\beta, \\ T_2(\beta) &= \frac{\lambda\pi}{2}\cos 2\beta + \frac{\lambda^2\pi^2}{4}\left[(2k-1)\cos 2\beta + \frac{1}{2}\cos 4\beta\right], \\ T_3(\beta) &= \frac{\lambda\pi}{2}\cos 2\beta + \frac{\lambda^2\pi^2}{4}\left[(2k-1)\cos 2\beta + \frac{1}{2}\cos 4\beta\right] + \\ &+ \frac{\lambda^3\pi^3}{8}\left\{[1+(2k-1)^2]\cos 2\beta + \frac{1}{4}(2k-1)\cos 4\beta + \frac{1}{6}\cos 6\beta\right\}. \end{aligned} \tag{8}$$

The general solution has the form:

$$T(\beta) = \sum_{n=1}^{\infty} \chi_n(\lambda)\cos 2n\beta.$$

The convergence of the process of the successive approximations is fairly easy to prove; the radius of convergence satisfies the inequality:

$$|\lambda| < 0.185. \tag{9}$$

By limiting the solution to members of not higher than the third order for λ, we obtain for the length of the arc of the envelope:

$$s = \frac{|\lambda|}{bq_0^2}\left|1 + \frac{\lambda^2\pi^2}{16}\right|, \tag{10}$$

whence, from the given length of the arc, λ may be found. In the same approximation, the equations of the outline of the envelope have the form:

$$\begin{aligned} x &= -\frac{\lambda}{2\pi b q_0^2}\left[1 + \frac{\lambda\pi}{2} + \frac{\lambda^2\pi^2}{4}(2k-1)\right]\cos\alpha, \\ y &= -\frac{\lambda}{2\pi b q_0^2}\left[1 - \frac{\lambda\pi}{2} - \frac{\lambda^2\pi^2}{4}(2k-1)\right]\sin\alpha, \end{aligned} \tag{11}$$

i. e. in this approximation, the envelope is elliptical in chape and is elongated in the direction perpendicular to velocity at infinity.

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PHYSIK

ÜBER PERMUTATIONSENTARTUNG IM VEKTORMODELL DES ATOMS

Von M. MARKOV

(Vorgelegt von S. Wawilow, Mitglied der Akademie, d. 25. IV. 1935)

Für zwei äquivalente p-Elektronen leitet van Vleck (1) die folgende Identität ab:

$$2\vec{s_i}\vec{s_j} = -(\vec{l_i}\vec{l_j})^2 - (\vec{l_i}\vec{l_j}) + \frac{1}{2}, \qquad (1)$$

wo $\vec{s_i}$, $\vec{s_j}$ Spinmomente, $\vec{l_i}$, $\vec{l_j}$, orbitale Momente bezeichnen.

Diese Identität wird unter Benutzung des Pauli-Prinzips abgeleitet (die resultierenden Momente sind nur der Werte 2,0; 1, 1; 0,0 fähig). Das Ergebnis ist, dass das Pauli-Prinzip den Winkel zwischen den Spinmomenten der Elektronen eindeutig bestimmt, sobald der Winkel zwischen den orbitalen Momenten vorgegeben ist.

Wir wollen nun zeigen, dass aus der allgemeinen Permutationstheorie Identitäten von der Art der Identität (1) entspringen, die für beliebige äquivalente Elektronen gelten.

Betrachten wir zwei äquivalente Bahnen im Atom, die wir mit i und j bezeichnen. Die entsprechenden Quantenzustände sind mit $\varphi_1 = (m_i s_i / q_i s_i)\ (m_j s_j / q_j s_j)$ gegeben. Der Zustand $\varphi_2 = (m_i s_i / q_j s_j)\ (m_j s_j / q_i s_i)$ kann aus dem Zustand φ_1 auf zweierlei Weisen erhalten werden. Entweder durch Vertauschung (q, s) der Koordinaten, oder durch Vertauschung (m, s) der Quantenzahlen.

Es sei p_{ij}^m der Operator der Vertauschung der orbitalen Momente, p_{ij}^s der Operator der Spinmomente.

Es folgt also:

$$p_{ij} = p_{ij}^m p_{ij}^s = p_{ij}^q p_{ij}^s.$$

Die Eigenwerte von p_{ij} seien k. Also $p_{ij}^m p_{ij}^s = k$.

Da $p_{ij}^{s^{-1}} = p_{ij}^s$, so folgt $p_{ij}^m = k p_{ij}^s$.

Der Operator p_{ij}^m hat folgende Form (2):

$$p_{ij}^m = \sum_0^{2l} \alpha_n (\vec{l_i}\vec{l_j})^n,$$

wo $(l_i l_j)$ das skalare Produkt der orbitalen Momente bezeichnet und α_n bestimmte Zahlenkoeffizienten sind.

Wir haben weiter

$$p_{ij}^{s} = \frac{1}{2}(1 + 4\vec{s_i}\vec{s_j}),$$

d. h.

$$\frac{1}{2}(1 + 4\vec{s_i}\vec{s_j}) = \frac{1}{k}\sum_{0}^{2l}\alpha_n(\vec{l_i}\vec{l_j})^n. \qquad (2)$$

Die Beziehung zwischen den Winkeln $(\overset{\wedge}{s_i s_j})$ und $(\overset{\wedge}{l_i l_j})$ ist also eine Folge der Austauschentartung. Da die Eigenwerte des Vertauschungsoperators ± 1 sind, so folgt:

$$\frac{1}{2}(1 + 4\vec{s_i}\vec{s_j}) = \mp\sum_{0}^{2l}\alpha_n(\vec{l_i}\vec{l_j})^n. \qquad (2')$$

Das Pauli-Prinzip verbietet das Plus-Zeichen in (2'); z. B. für p^2-Elektronen (2): $p_{ij}^{m} = (\vec{l_i}\vec{l_j})^2 + (\vec{l_i}\vec{l_j}) - 1$.
Es folgt also

$$\frac{1}{2}(1 + 4\vec{s_i}\vec{s_j}) = \mp[(\vec{l_i}\vec{l_j})^2 + (\vec{l_i}\vec{l_j}) - 1]. \qquad (3)$$

Die erste Identität fällt mit der van Vleck'schen (1) zusammen. Für die vorgegebenen Werte von $L=2, 1, 0$ erhalten wir die möglichen Werte für S: 0, 1, 0. Würden wir in (3) das Plus-Zeichen wählen, so würden wir verbotene Terme erhalten.

Für d^2-Elektronen erhalten wir:

$$\frac{1}{2}(1 + 4\vec{s_i}\vec{s_j}) = \mp\frac{1}{36}[(\vec{l_i}\vec{l_j})^4 + 6(\vec{l_i}\vec{l_j})^3 - 13(\vec{l_i}\vec{l_j})^2 - 90(\vec{l_i}\vec{l_j}) - 36]. \qquad (4)$$

Die Eigenwerte von $(l_i l_j)$ sind 4, 0, —3, —5, —6.
Sie entsprechen den Werten $L=4, 3, 2, 1, 0$.
Wählen wir das Minus-Zeichen und setzen wir die Werte für L ein, so erhalten wir für S: 0, 1, 0, 1, 0, d. h. die erlaubten Terme ^1S, ^3P, ^1D, ^3F, ^1G.
Man kann versuchen den Vertauschungsoperator, als Funktion von verschiedenen beobachtbaren Grössen auszudrücken, um die Art der Wechselwirkung dieser beobachtbaren Grössen aufzufinden, die zum Pauli-Prinzip führt.

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CHIMIE PHYSIQUE

SUR LA DENSITÉ ANORMALE DES EAUX DES COUCHES PROFONDES DU LAC BAÏCAL.

Par J. MENDELEJEV

(Présenté par V. Vernadskij, de l'Académie, le 7. IV. 1935)

Des considérations théoriques ont conduit l'auteur à chercher dans les couches profondes des eaux douces peu minéralisées,—à température relativement homogène et se trouvant dans des conditions de remuement minimum,—un mécanisme propre à accumuler par sélection gravifique les molécules les plus lourdes de l'eau, soit d'origine isotopique, soit molécules de structure moléculaire complexe [$(H_2O)_n$, A. Gorbov (1)]. Dès le commencement de 1933 je me suis entendu avec le directeur de la Station limnologique du lac Baïkal de l'Académie des Sciences de l'URSS, G. J. Vereščagin, pour l'étude en commun de la densité des couches profondes du bassin d'eau douce le plus profond de la terre,—le lac Baïkal (profondeur 1741 m).

Dans la même année, 1933, G. J. Vereščagin me remetta des échantillons de l'eau du Baïkal tirée d'une profondeur de 1200 m. En collaboration avec L. D. Chudiakova j'étudiai ces échantillons avec grand soin au moyen d'un pycnomètre (d'une capacité de 100 cm^3) et je constatai que, malgré une distillation réitérée, l'eau examinée manifestait des traces de condensation d'environ 3 unités de la sixième décimale, grandeur, il est vrai, dépassant à peine la limite de précision de la méthode alors employée (1).

J'ai construit depuis un instrument spécial—un aréomètre à chaînette à immersion complète—donnant la densité d'un liquide jusqu'à la septième décimale et repris en 1934 avec cet instrument l'étude de l'eau du lac Baïkal sur place. Au cours des travaux de l'expédition de la Station limnologique les collaborateurs de la Station ont opéré l'extraction d'échantillons d'eau de différentes couches jusqu'à une profondeur de 1650 m. Les échantillons provenant des plus grandes profondeurs ont été tirés le 31 août et le 1-er septembre 1934, à 5 kilomètres du rivage en face du cap Utchan de l'île Olkhon. J'ai étudié ensuite tous les échantillons dans le laboratoire de la Station limnologique du Baïkal, située au bord du lac, dans le bourg de Listvenitchnoié. Tous les échantillons, distillés avec soin dans un appareil en verre, ont été

comparés à l'aide de l'aréomètre à chaînette à immersion complète—avec de l'eau ordinaire, distillée avec les mêmes précautions. Comme source de cette eau «ordinaire» j'avais pris: 1) de l'eau de la surface du lac Baïkal; 2) de l'eau de pluie prise à la gouttière du laboratoire; 3) de l'eau de source fournie par le ruisseau Krestovka qui se jette dans le lac Baïkal près du bourg de Listvenitchnoié. Ces trois échantillons d'eau, après la distillation, n'ont présenté aucune différence de densité à la septième décimale près.

La table suivante donne les densités observées pour les échantillons d'eau distillée tirés de différentes couches du lac Baïkal.

Table 1

Eau distillée

Profondeur en mètres	Densité à 4°	Accroissement de la densité en unités de la 7me décimale
0	1.0000000	0
600	1.0000007	7
1000	1.0000029	29
1200	1.0000027	27
1400	1.0000030	30
1600	1.0000044	44
1650	1.0000056	56

La figure (v. p. 107) donne la courbe de la densité en fonction de la profondeur; les profondeurs y sont indiquées sur l'axe des abscisses, en mètres; les accroissements de la densité, en unités de la 7me décimale, sont portés sur l'axe des ordonnées.

Ou peut donc conclure que: 1) la densité de l'eau à la surface du lac Baïkal ne diffère point de la densité de l'eau ordinaire; 2) avec la profondeur, la densité de l'eau du lac Baïkal s'accroît; 3) à la profondeur maxima de notre table, 1650 m, la condensation de l'eau du Baïkal atteint une valeur maxima de 56 unités de la 7me décimale.

J'ai effectué ensuite, à Leningrad, dans le laboratoire de l'Institut métrologique de l'URSS, la comparaison du même échantillon (profondeur de 1650 m) avec l'eau distillée de la Néva, et constaté une condensation de densité de 54 unités de la 7me décimale, donc une valeur du même ordre.

Il reste à mentionner que l'inflexion de la courbe dans la région des profondeurs de 1200 m correspond à une inflexion analogue des courbes données antérieurement par G. J. Vereščagin pour la teneur de l'eau du Baïkal en O_2 et en CO_2 en fonction de la profondeur, ce qu'il explique par les conditions du remuement des eaux du lac Baïkal.

Parallèlement j'ai déterminé aussi par la même méthode les densités des mêmes échantillons d'eau non distillée. Les résultats sont donnés dans la table 2.

L'excédent de densité de l'eau non distillée du Baïkal s'explique dans sa plus grande partie par sa minéralisation. Mais la quatrième colonne de la table 2 montre que l'excédent d'isotopes y joue aussi un certain rôle.

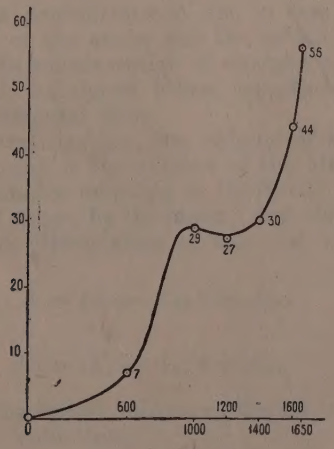
Il reste à remarquer que l'eau de densité anormale des profondeurs du Baïkal peut n'être point identique à «l'eau lourde» obtenue par A. Lewis en 1933 au moyen de l'électrolyse et contenant l'isotope lourd de l'hydrogène.

Table 2

Eau non distillée

Profondeur en mètres	Densité à 4°	Accroissement de la densité en unités de la 6me décimale	Différence des densités de l'eau non distillée et de celle distillée
0	1.000067	67	67
600	1.000074	74	73
1000	1.000077	77	74
1200	1.000078	78	75
1400	1.000078	78	75
1600	1.000083	83	77

En effet, dans la sélection gravifique effectuée dans les profondeurs il n'y a que le poids des molécules qui compte; dans ces conditions les molécules à isotopes lourds de l'oxygène tendront à s'accumuler dans les profondeurs au même titre que les molécules à hydrogène lourd. Les isotopes lourds de



l'oxygène se rencontrant dans l'eau ordinaire en proportion neuf fois plus grande que les isotopes lourds de l' hydrogène, l'eau des profondeurs du Baïkal

doit présenter un excédent de même ordre de grandeur de molécules à oxygène lourd. L'étude des eaux profondes du lac Baïkal, que je suis en train de poursuivre, a pour objet de vérifier ces suppositions.

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PHYSICAL CHEMISTRY

THE DONNAN EFFECT IN ULTRAFILTRATION OF COLLOIDAL SOLUTIONS

By A. RABINOVIČ (RABINOVITSCH), Corresponding Member of the Academy, P. VASILJEV and T. GATOVSKAJA

If the ultrafiltration of a colloidal solution through a membrane nonpermeable for colloidal particles is carried out slowly enough, the solutions on both sides of the membrane (colloidal solution—I and ultrafiltrate—II) are at any given moment in mutual equilibrium. Therefore, the ionic equilibrium in this system must satisfy the Donnan equations for membrane equilibrium (1) (e. g. for a positive sol):

$$A_{II} = K_{II}, \tag{1}$$

$$A_I = K_I + M + 1, \tag{2}$$

$$K_{II} \cdot A_{II} = K_I \cdot A_I, \tag{3}$$

$$E = \frac{RT}{nF} \ln \frac{K_I}{K_{II}} = \frac{RT}{nF} \ln \frac{A_{II}}{A_I}, \tag{4}$$

where A and K are the concentrations, or, in case of more concentrated solutions, the activities of the anion and the cation, respectively, in solutions I and II, M^+ is the concentration of charged colloidal particles; E is the membrane potential. As shown below, equations (1) and (3) are well supported by our experimental data.

In the process of ultrafiltration, the volume of the initial sol is diminished by the same amount as the volume of the ultrafiltrate is increased. Let us denote the magnitudes referring to the initial state of the sol by the index $_s$; those of the final state—by the index $_r$, and those of the ultrafiltrate—by $_u$. Assuming complete dissociation of sols and ultrafiltrates, it is easy to show that

$$A_r = (A_s - A_u)\, n + A_u, \tag{5}$$

and

$$K_r = (K_s - A_u)\, n + A_u, \tag{6}$$

where n is the ratio of the initial volume of the sol to its final volume after ultrafiltration (volume reduction).

Combining these equations with those of Donnan, we can deduce a general expression for the concentration (activity) of the ions of both signs in the ultrafiltrate at any given volume reduction n. By multiplying respectively the left and right parts of equations (5) and (6) and by substituting

the product into equation (3), we obtain, after simple algebraic operations, the following quadratic equation:

$$A_u^2(n-2) + A_u(A_s + K_s)(n-1) + A_s K_s n = 0. \quad (7)$$

The solution of this equation gives two roots:

$$A_u = K_u = \frac{(A_s + K_s)(n-1) \pm \sqrt{(A_s + K_s)^2 (n-1)^2 - 4A_s K_s n (n-1)}}{2(n-2)}. \quad (8)$$

The analysis of equation (8) shows that the solutions with the plus sign before the radical give infinitely great values for $A_u = K_u$ at $n=2$ and negative values of concentration at values of n ranging between 1 and 2. Solutions with minus sign before the radical yield a continuous series of positive values for the concentrations, in accord with experimental data; only at $n=2$ an indefinite solution is obtained, which is, however, easily disclosed by the method of l'Hospitale.

By solving equation (8) at given values of A_s and K_s and variable n, we get a series of values for $A_u = K_u$, which may be plotted against n and give then a smooth curve dropping considerably at low values of n and following a nearly linear trend, parallel to the axis of abscissae, at high values of n. This peculiar form of the function accounts for the apparent «constancy» of the composition of the ultrafiltrates, which has been observed by several authors.

Taking various ratios $\frac{A_s}{K_s}\left(\text{or } \frac{A_s - K_s}{K_s}\right)$ for initial sols and solving equation (8) under these assumptions for various values of n, we obtain a family of curves, where the drop of ionic concentration from initial sol to ultrafiltrate is the more pronounced the higher the ratio $\frac{A_s}{K_s}$, i. e. the higher the content of colloidal particles in relation to the electrolyte.

Combining equation (8) with (5) and (6), it is easy to obtain analogous expressions for the concentrations of both ions in the residual sols after ultrafiltration (A_r and K_r). The corresponding curves, expressing A_r and K_r as functions of n, have a quasi-linear form, which is also supported by experiments.

The above theory has been verified in a serise of electrometric measurements on various sols of ferric hydroxide preparde as previously described [2] and dialysed in collodion bags for various time intervals, which yielded sols with varying ratios $\frac{A_s}{K_s}$ or $\frac{M}{K_s}$.

The potentiometric measurements of the activity of Cl ions were made with calomel electrodes [2], those of the activity of H ions by means of glass electrodes [3]; the volume reduction n was calculated from analytical determinations of Fe in sols and residues. In the sols studied the Cl ions play the part of compensating ions (Gegenionen), and, apart from them, only H^+ ions are present in considerable amount; in sufficiently dialysed sols only traces of NH_4^+ and Fe^{+++} can be detected.

Table 1 gives, as an example, data showing how accurately equations (1) and (3) of Donnan's theory apply in case of one of the many studied Fe_2O_3 sols (sol 3). The activities of the ions are expressed in terms of pH and pCl, their product—as the sum of pH+pCl.

The slight discrepancy between pH and pCl in the ultrafiltrates is due to the presence of small amounts of other cations (NH_4^+ and Fe^{+++}) in this insufficiently dialysed sol. The constancy of the product of anion and cation activities holds well for all ultrafiltrates, the initial sol, and residues after

ultrafiltration. The same table shows that the concentration of both ions in the ultrafiltrates remains practically constant, as required by equation (8), the volume of the initial sol being reduced by n=3.3—7.0.

Table 1

Solution No.		n	pCl	pH	pCl + pH
Ultrafiltrate	1	3.04	1.92	—	—
	2	4.68	1.93	1.96	3.89
	3	6.0	1.91	2.01	3.92
	4	8.0	1.93	2.01	3.95
Sol			1.00	1.92	2.00	3.92
Residue	1	3.04	1.79	2.23	4.02
	2	4.68	1.68	2.25	3.93
	3	6.0	1.61	2.30	3.91
	4	8.0	1.54	2.40	3.94

According to our theory, however, this constancy is not a matter of principle and must not hold at small values of n. Table 2 shows the coincidence of experimental values of A_u (for Fe_2O_3 sol 1) with those calculated from equation (8).

Duclaux ([4]), and Wiegner and Pallmann ([5]) ascribed a fundamental importance to the constancy of composition of ultrafiltrates, obtained in their measurements. They identified the composition of the ultrafiltrate with that of the intermicellar liquid. As noticed by Bolam ([6]), the constancy of ultrafiltrates is inconsistent with the thermodynamical theory of Donnan. Our theory gives an alternative solution of this problem.

Table 2

n	pCl_u exp.	pCl_u calc.
1.65	2.45	2.48
2.81	2.48	2.52
3.44	2.55	2.53
4.31	2.46	2.55
5.72	2.46	2.57
9.0	2.52	2.59

As was shown by the analysis of equation (8), the ionic composition of the ultrafiltrates must differ from that of the initial sol the more the higher the ratio of particles to the electrolyte content in the sol. This ratio increases with the duration of dialysis. In accordance with this, Table 3 shows that in a series of variously dialysed sols the difference $Cpl_u - pCl_s$ increases with growing $\frac{M}{K_s} = \frac{A_s - K_s}{K_s} = \frac{a_{Cl} - a_H}{a_H}$. In slightly dialysed sols this effect is quite absent.

The difference between the concentraitons of the compensating ion in the sol and the ultrafiltrate, shown in Table 3, is quite analogous to the «suspension effect», found by Wiegner and Pallmann ([5]) in their investigations on ultrafiltration, sedimentation, and centrifugation of colloidal systems. This effect, however, has received in their papers an explanation

Table 3

Sol No	$\frac{M}{K_s}$	pCl_s	pCl_u	$pCl_u - pCl_s$
2	0.20	1.92	1.92	0.00
3	0.45	2.12	2.13	0.01
6	0.74	2.11	2.15	0.04
1	1.35	2.28	2.44	0.16
5a	3.84	2.88	3.29	0.41
7	4.36	2.50	2.82	0.32
4a	7.69	2.79	3.33	0.54

which calls forth some doubts from the thermodynamical point of view. It follows from their considerations that two identical electrodes, dipped into various parts of a colloidal system, after its separation by the above-mentioned means, and short-circuited, must yield a current, which is quite equivalent to the recognition of possibility of a *perpetuum mobile* of second kind.

Wiegner and Pallmann did not take into consideration that the separation of a colloidal system requires a certain amount of work, a part of which creates an opposite potential difference inside the system (e. g. membrane potential), which compensates the difference of the potentials of reversible electrodes dipped into various parts of the system.

Moreover, the molecular-kinetic conception proposed by the above-mentioned authors as an explanation of the effect discouvered by them, has not been supported by our investigations, as we have shown that the composition of the ultrafiltrates and that of the intermicellar liquid must be different. According to our theory, the Wiegner effect can be quantitatively explained on the basis of Donnan's membrane equilibrium*.

The «suspension effect» is observed also when the colloidal system is separated by centrifugation; as stated by Tiselius ([8]), the conditions of Donnan's equilibrium hold equally for sedimentation and centrifugation.

As shown above, the curves expressing the dependance of A_r and K_r upon n (volume reduction in ultrafiltration) must be quasi-linear. This is well supported by experimental data. In Table 4, the values of $A_r = (a_{Cl})_r$ observed on Fe_2O_3 sol 3 are compared with those calculated according to our theory.

Table 4

n		1.00	3.26	4.34	5.10	7.0
$A_r \cdot 10^2$	exp.	7.59	11.2	12.3	13.8	16.6
	calc.	—	11.0	13.0	14.4	18.3

The linear trend of this curve has been deduced from the theory of Wiegner and Pallmann, but finds another explanation from the point of view of our theory.

The slight discrepancies observed between the experimental and the calculated values obviously can be explained by the inaccuracy of the assumption of complete dissociation in sols concentrated by ultrafiltration.

Analogous measurements have been made on a series of negative sols (WO_3, TiO_2, V_2O_5) and suspensions; the existence of «suspension effect», the apparent constancy of the composition of the ultrafiltrates, and the quasi-linear change of the activity of compensating ions in sol residues after ultrafiltration have been found as well for these systems.

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* The possibility of such an explanation of Wiegner's effect has been pointed out quite independetly by B. P. Nicolski ([7]).

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BIOCHEMIE

DIE EINWIRKUNG DES PARAPHENYLENDIAMINS AUF DIE CHEMISCHEN PROZESSE IM QUERGESTREIFTEN MUSKEL

Von A. PARŠIN (PARSCHIN)

(Vorgelegt von A. Bach, Mitglied der Akademie, d. 15. IV. 1935)

Vor einigen Jahren habe ich im Zentralinstitut für Erforschung der professionellen Krankheiten in Moskau eine Untersuchung über die Einwirkung des Paraphenylendiamins auf das isolierte Herz warmblütiger Tiere ausgeführt (1).

Im Gegensatz zu den Untersuchungen von Meissner (2), der nachgewiesen hatte, dass Paraphenylendiamin auf das isolierte Froschherz keine Wirkung ausübt, habe ich eine sehr starke Wirkung des Paraphenylendiamins auf den Herzmuskel beobachten können.

Es hat sich erwiesen, dass Paraphenylendiamin einen nicht umkehrbaren Herzspasmus, der zu einem systologischen Stillstand des Herzens führt, hervorruft, wobei der Wirkungsgrad des Paraphenylendiamins sowohl von seiner Konzentration, als auch von der Wirkungsdauer abhängt.

Gleichzeitig wurden in demselben Laboratorium Versuche über die Wirkung des Paraphenylendiamins auf das isolierte Herz kaltblütiger Tiere angestellt [A. M. Breitburg und S. J. Pisarev (1)], weiterhin auf die isolierten Gefässe [R. M. Ainbinder (1)], auf ein Nervenmuskelpräparat [A. M. Breitburg, V. S. Rajevskij und L. S. Radčenko (1)], auf die isolierten Bronchen und auf die Gebärmutter [A. M. Breitburg und L. S. Radčenko(1)].

Alle diese Versuche haben unzweifelhaft erwiesen, dass Paraphenylendiamin ausschliesslich nur ein Muskelgift ist, das einen nicht umkehrbaren Spasmus des quergestreiften und glatten Muskels hervorruft, ohne auf die Nerven zu wirken.

Auch Meissner (2) hat die spasmatische Wirkung des Paraphenylendiamins beobachtet, wenn er den Fröschen 0.25—0.6 mg Paraphenylendiamin auf ein Gramm des Eeigengewichtes einführte. Nach Verlauf einiger Zeit zeigten sich fibrilläre Zuckungen einzelner Muskelgruppen, gewöhnlich in der Nähe der Injektionsstelle, die sich dann allmählich auf die ganze

quergestreifte Muskulatur verbreiteten; schliesslich trat eine vollständige Erstarrung ein.

Dieses Bild der Vergiftung durch Paraphenylendiamin haben auch meine Versuche vollständig bestätigt.

Bei Menschen, die, wie z. B. die Fellfärber, mit diesem Stoff arbeiten, zeigten sich im Fall einer Vergiftung mit Paraphenylendiamin Symptome von Bronchialasthma, die aller Wahrscheinlichkeit nach auch durch den Spasmus der Bronchenmuskulatur hervorgerufen werden.

Daraus wird es von selbst verständlich, dass die Ergründung des Chemismus der nach der Vergiftung mit Paraphenylendiamin auftretenden Erstarrung nicht nur eine theoretische, sondern auch eine grosse praktische Bedeutung besitzt.

Das Ziel der vorliegenden Arbeit bestand im Studium der Einwirkung des Paraphenylendiamins auf die chemischen Prozesse im quergestreiften Muskel.

Ich beschränkte mich dabei auf die Untersuchung der Einwirkung des Paraphenylendiamins auf den Umsatz der Kreatin-Phosphorsäure, der Adenosin-Triphosphorsäure (Pyrophosphat) und auf die Bildung der Milchsäure.

Die Methodik der Versuche bestand im folgenden:

In den Rückensack des Frosches (*Rana temporaria*) wurde eine mit Schwefel- oder Salzsäure genau neutralisierte Paraphenylendiaminlösung eingeführt. Sobald die Vergiftungserscheinungen scharf zutage getreten waren und der auf den Rücken gelegte Frosch, infolge des eingetretenen Spasmus der Extremitätenmuskeln, nicht mehr imstande war, die Normallage wieder einzunehmen, wurde er getötet.

Darauf wurde der m. gastrocnem. beider Extremitäten abgetrennt und in eine feuchte Kammer gesetzt.

Ein Muskel wurde zu Kontrollzwecken auf einem Uhrenglas belassen, der andere wurde einem indirekten Reiz durch den Induktionsstrom unteworfen (60 Schläge in 1 Minute, bei einer Entfernung von 29 cm zwischen der primären und der sekundären Spule. Der Reiz dauerte 15 Min. Unmittelbar darauf wurden der Muskel, der gearbeitet hatte, und der Kontrollmuskel in Porzellanmörsern in 10 cm^3 4% CCl_3COOH mit gut zerstossenem Glase zerrieben. Die Mörser und die Lösungen der Trichloressigsäure wurden vorher in einem grossen Exsikkator auf Eis abgekühlt.

Dem Trichloressigfiltrat wurde je 1 cm^3 zur Bestimmung des Gesamtphosphors (anorgan. P. und Phosphagen), des anorganischen Phosphors und des Pyrophosphats entnommen. Die Bestimmung der Phosphorfraktionen wurde nach Lohmann ([3]) ausgefürt, die des Phospors nach Lohmann und Jendrassik ([4]). Zur Bestimmung der Milchsäure wurden 4—5 cm^3 Trichloressigfiltrat genommen. Die Bestimmung erfolgte nach der Methode von Friedemann-Cotonio-Schaffer ([5]).

Die Ergebnisse der Versuche sind in der Tabelle veranschaulicht. Zum Vergleich wurden einige Versuche mit normalen Fröschen angestellt.

Der Phosphor ist in mg P_2O_5 auf 1 g des Rohgewichtes des Muskels ausgedrückt

№ des Versuchs	Datum, 1934	Das Gewicht des Muskels in g	Menge des eingeführten Paraphenylendiamins	Zeit der Entnahme des Muskels nach der Vergiftung	Charakter des Versuchs	Gesamtphosphor (anorgan. P und Phosphagen)	Anorganischer Phosphor	Phosphagen	Phosphormenge nach einer Hydr. von 7 Min. in NHCl	Menge des Pyrophosphats	Milchsäure in mg %
17	17 XI	0.81	normal. Muskel	—	in Ruhe . . .	0.75	0.58	0.17	0.85	0.1	30
					gereizt . . .	0.81	0.75	0.06	0.85	0.04	358
19	20 XI	0.56	»	—	in Ruhe. . .	1.0	0.56	0.44	1.16	1.16	27
					gereizt . . .	1.1	1.0	0.1	1.16	0.06	190
20	21 XI	0.58	»	—	in Ruhe. . .	0.98	0.58	0.4	1.13	0.15	20
					gereizt . . .	1.01	0.96	0.05	1.13	0.12	283
11	10 XI	0.37	2 cm^3 m/10	1 St.	in Ruhe. . .	1.08	0.77	0.31	1.37	0.29	210
					gereizt . . .	1.16	1.01	0.15	1.43	0.27	356
12	11 XI	0.4	»	1 St.	in Ruhe. . .	1.1	0.65	0.45	1.42	0.32	112
					gereizt . . .	1.1	0.94	0.07	1.42	0.32	137
13	13 XI	0.49	1 cm^3 m/10	1 St. 30 M.	in Ruhe. . .	1.02	0.87	0.15	1.16	0.14	253
					gereizt . . .	1.08	1.04	0.04	1.2	0.12	261
39	19 XII	0.32	»	35 M.	in Ruhe. . .	1.15	0.75	0.4	1.5	0.45	126
					gereizt . . .	1.25	1.12	0.13	1.5	0.25	281
30	4 XII	0.5	1 cm^3 m/50	1 St.	in Ruhe. . .	0.88	0.56	0.32	1.02	0.14	240
					gereizt . . .	0.94	0.72	0.22	1.1	0.07	290
36	13 XII	0.37	»	1 St.	in Ruhe. . .	1.13	0.59	0.54	1.43	0.3	120
					gereizt . . .	1.18	0.97	0.21	1.43	0.25	148
37	13 XII	0.33	»	1 St.	in Ruhe. . .	1.33	0.84	0.49	1.69	0.36	130
					gereizt . . .	1.42	1.21	0.21	1.54	0.12	257
25*	27 XI	0.44	1 cm^3 m/100	1 St.	in Ruhe. . .	1.09	0.68	0.41	1.29	0.2	30
					gereizt . . .	1.13	0.86	0.27	1.29	0.16	168
26*	28 XI	0.34	»	1 St.	in Ruhe. . .	1.29	0.91	0.38	1.5	0.21	52
					gereizt . . .	1.32	1.02	0.3	1.55	0.23	106

* Erstarrungserscheinungen wurden nicht beobachtet.

Wie bekannt, sind die Erscheinungen der Muskelstarre, die nach der Wirkung dieses oder jenes chemischen Stoffes eintreten, in den meisten Fällen mit einer gesteigerten Erzeugung von Milchsäure verbunden. In einigen Fällen wird sogar eine direkte Proportionalität zwischen der Entwicklung des Erstarrungsprozesses und der Menge der erzeugten Milchsäure beobachtet. So z. B. bei der Hervorrufung der Erstarrung durch Koffein und Chloroform, wie es Matsuoka ([6]) gezeigt hat.

Aus den in der Tabelle angeführten Ergebnissen der Versuche ist ersichtlich, dass die sich nach der Wirkung des Paraphenylendiamins entwickelnde Muskelstarre auch mit einer gesteigerten Erzeugung von Milchsäure verbunden ist. Aber die bei dieser Vergiftung entstehenden chemischen Prozesse zeigen eine Reihe von besonderen Merkmalen. Insbesondere fehlt die Zersetzung des Pyrophosphats, die bei Todes-, Wärme-, Koffein-, Äther- und Chloroformstarre eintritt ([7]). Es konnte auch keine Wirkung des Paraphenylendiamins auf den Umsatz der Kreatin-Phosphorsäure festgestellt werden.

Somit wird bei der Paraphenylendiaminvergiftung nur der Bildungsprozess der Milchsäure gestört. Infolge der starken Vermehrung der Milchsäure bei dieser Vergiftung wird der Unterschied der Menge der Milchsäure im arbeitenden und ruhenden Muskel im hohen Masse ausgeglichen.

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GEOCHEMISTRY

ON THE OCCURRENCE OF VANADIUM IN FOSSIL COALS

By V. SILBERMINTZ

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Of recent times quite a lot of attention has been devoted to the matter of the occurrence of vanadium in sedimental rocks. A considerable amount of material has been accumulated, the basic deductions from which are given in the work of Jost (1). But not nearly enough has been done towards elaborating the subject of the vanadium content in fossil coals. It is only in the case of the asphaltites that we have a fair number of determinations, and a large number of these show a high quantity of vanadium. By a goodly number of investigators, this phenomenon is considered as characteristic, even, for the asphaltite coals, in contrast to coals of vegetable origin, in which accumulation of vanadium is not observed. The contradictory opinions that have been advanced with respect to this question in recent times are to a degree due to unsatisfactory petrographic information about the materials treated.

No doubt, if reliance were only on determinations known up to the present time, it might be considered that the contrasting of coals of vegetable origin as being characterized by a low vanadium content and of coals of bituminous origin as distinguished by a high vanadium content, as was done not long ago by Orlov (2, 3), was quite just.

All of the few determinations of vanadium that have been made for coals of undoubted vegetable origin do, indeed, always give figures of inconsequential magnitude. The maximum quantity does not exceed the limits of 0,1 to 0.2 per cent (with regard to the ash). Such figures as these we find, for example, in the works of Mingaye, Vorobiov, Thilo, and others (4,5,6).

In our investigations on the occurrence of the rare elements in the ash of fossil coals, we have paid special attention to the determination of vanadium. It seemed to us especially desirable to obtain new geochemical data, which might help the search for the sedimentary deposits of this element, so important for our industry.

The possibility of studying a great number of samples was completely guaranteed by the possession of a method that we had previously developed

while investigating the Kerch iron ores (7). A test of this method proved, in the case of a series of parallel analyses done according to Hillebrand, its feasibility in the present instance.

Much of the material that was subjected to investigation was obtained in part from museums and from geologists and in part was specially collected in the Donetz Basin and the Khumara, Tkvibuli, and Tkvarcheli deposits. Altogether, over 800 samples were at our disposal, on 500 of which analyses for vanadium were made. Investigation of the remaining samples could not be performed owing to the insufficient quantity of ash obtained when this or that coal was burnt (in many cases owing to the insufficient amount of the original material).

Taking into consideration the muddled state of the question of content of rare elements in coal, we made no particular choice of material. Among our samples are coal of the most varied types and structures. Attempting to diminish the quantity of clastic ash, we carefully separated the distinguishable parts of the overlying and the underlying rock. The selected material was reduced to ashes by burning in a muffle furnace (at a temperature of 750°); the ashes were then ground and submitted to analysis. Simultaneously the general quantity of the ash was also determined, since it might be a useful thing to know for further purposes.

The results obtained are shown in Table 1.

Table 1

Name of deposit	Number of determinations	Average content of V_2O_5 in percentages	Fluctuation in content of V_2O_5
Donetz Basin	266	0.08	0.02—0.34
Tkvibuli	39	0.13	0.07—0.27
Tkvarcheli	17	0.10	0.05—0.17
Khumara	15	0.10	0.05—0.16
Pechora River Basin	50	0.08	0.02—0.31
Karaganda	8	0.06	0.04—0.08
Suchan	6	0.07	0.04—0.11
Sakhalin	4	0.10	0.08—0.11
Cheremkhovo	5	0.06	0.03—0.09
Kuznetsk Basin	4	0.09	0.08—0.11
Moscow Basin	3	0.12	0.09—0.16
Spitzbergen	2	0.09	0.07—0.11

Our data from these many samples, broadly illustrating the distribution of vanadium in almost all the coal beds of the USSR, definitely confirm the previous suppositions about the insignificance of the accumulation of vanadium in coal. The amounts obtained by us differ but little from the concentrations of V in clays, argillaceous shales, certain phosphorites, and so on. Bearing in mind that the coals investigated by us can be considered in all respects sufficiently varied in type, it would seem to be fully established that important accumulations of vanadium in coals of vegetable origin are quite unusual.

Consequently, a phenomenon which we found in one of the samples of coal of the Jurassic Age furnished us by Prof. A. A. Chernov is especially unexpected and interesting. In this coal, which was a well-preserved carbonized woody material, the quantity of vanadium proved to be equal to 1.22 per cent. Quite naturally, we conducted a further investigation on other samples of analogous age, structural characteristics and—most important of all—regional relations with the Ural Mountain Range. The next investigations of samples from the Ishmukhametova deposit (the Bashkir Autonomous Soviet Republic) showed yet more astounding results (5.56 p. c. V_2O_5, 1.42 p. c. Cr_2O_3, and 0.84 p. c. NiO). Finally, a series of samples from the Jurassic deposits of the eastern slopes of the Northern Urals (the basin of the North Sosva River) gave a number of most curious figures (see Table 2).

Table 2

№	Deposit	Percentage V_2O_5	Percentage of ash
1	Right Bank of Malaya Synia River, outcrop 51	1.22	Not determined
2	Ishmukhametova	5.56	4.53
3	Bolshaya Leplia River, outcrop 14, samples *a*	8.79	4.78
4	Bolshaya Leplia River, outcrop 14, samples *b*	8.64	1.79
5	Bolshaya Leplia River, outcrop 14, samples *c*	0.64	2.96
6	Niays River, samples *a*	3.80	1.62
7	Niays River, samples *b*	4.60	3.95
8	Niays River, samples *c*	3.50	5.70
9	Verkhniaya Sosva, Yany-Mania River	0.84	5.87
10	Verkhniaya Sosva, below mouth of Mania *	4.86	2.52
11	Verkhniaya Sosva, Tolia River, outcrop 17 *	0.56	6.10

The great majority of coals that show such a high vanadium content belong to the clareno-vitrene type and often have a plainly lignite structure. Apparently the quantity of clastic ash in them must be admitted to be quite insignificant. The chemical composition of two samples of ash, according to analyses by G. V. Kniazheva, definitely points to the presence of ash of infiltrational origin (the preponderance of mobile compounds, with a small amount of silica). This is evidenced, too, by the high percentage of ash—too high to consider the latter as entirely primary. And so, the unusually high percentage of vanadium is due only to ash that is both primary and infiltrational.

The origin of vanadium (at least, of a large part of it) from the second source, connected with local conditions of some kind, is most probable. If it were not so, then we would have found a high percentage of vanadium in the clareno-vitrene coals and lignites of other deposits which we investigated. However, nowhere at all was such a phenomenon observed.

* Sample 10 was taken from a bed having, according to the data given by geologist Sirin, a thickness of 1.5 meters, and sample 11 from a bed having a thickness of 5 meters.

On both slopes of the Urals it is not hard to see these local conditions: in the processes of the breaking down of the Ural chain, especially in the belts of basic rocks which often contain considerable accumulations of vanadium in the numerous segregations of titanomagnetites. One can easily see how great might be the quantity of vanadium segregated out of these massifs from the end of the Permian epoch up to the present time. A part of this vanadium, under one or another condition, might have been absorbed by the materials of the future coal beds. Such may have been the fate, too, of chromium, nickel, and possibly other still rarer elements.

Taking into consideration the possibility of such a process, one may also speculate on the possibility of the occurrence of vanadium minerals in the rocks of the coal-bearing strata as well. In this case coal might be looked on as a medium into which rare metals have subsequently shifted. Such coal would appear to be a reflection, so to speak, of the content of the whole geological series in which it is contained, that is to say, might be made an important leading clue when seeking for new sedimental deposits of vanadium.

The fact established by us of the existence of unusually high concentrations of vanadium in the ash of fossil coals undoubtedly points towards a number of further investigations in the field of this new and exceptionally interesting problem.

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SEISMOLOGIE

ÜBER DIE SEISMISCHE PROSPEKTION NACH DER METHODE DER REFLEKTIERTEN WELLEN

Von E. KORIDALIN und S. MASARSKIJ

(Vorgelegt von S. Wawilow, Mitglied der Akademie, d. 25. IV. 1935)

Auf Grund der Arbeiten des Seismologischen Instituts der Akademie der Wissenschaften über die Anwendung der seismischen Methoden für Zwecke der Geologie und der geologischen Prospektion (1) konnte eine Reihe von Aufgaben für die weitere Einbürgerung dieser Methoden in der Produktionspraxis gestellt werden.

Nach den Arbeiten vom J. 1929—30, die auf Bestellung des Trustes «Grosnephtj» durchgeführt worden sind, hat das Seismologische Institut eine Reihe von Modellen der Feldseismographen im Laufe der folgenden drei Jahre konstruiert. Die Mehrzahl dieser Seismographen gehört dem Typus der Elektroseismographen an. Die Registrierung erfolgt auf optischem Wege auf photographischem Papier mit Hilfe eines Oszillographen.

Es hat sich erwiesen, dass den Bedingungen der Feldarbeit am meisten ein elektromagnetischer Seismograph, der mit einem Zweilampenverstärker von niedriger Frequenz und einem sechsschleifigen Oszillographen versehen ist, entspricht (2).

In letzterer Zeit erregen die reflektierten Wellen ein grosses Interesse. Das Studium ihrer Ausbreitung ermöglicht eine sehr einfache und genügend genaue Lösung vieler Fragen der geologischen Prospektion. Diese Methode hat eine grosse Verbreitung und Bedeutung in den Vereinigten Staaten von Amerika bei der Untersuchung der naphtaführenden Gebiete und in den Arbeiten deutscher Forscher bei der Erforschung der Gletscherdicken in den Alpen und auf Grönland erlangt.

Wenn die seismischen Wellen auf die Scheidegrenze zweier Schichten fallen, wird ein Teil ihrer Energie reflektiert und auf die Erdoberfläche zurückgeworfen, wo er von den Seismographen registriert werden kann.

Nehmen wir an, wir hätten zwei Schichten (Abb. 1), in denen die Ausbreitungsgeschwindigkeit der seismischen Wellen mit v_1, und v_2 bezeichnet ist.

O bedeutet die Explosionsstelle, A das Apparat und H die Dicke der ersten Schicht. Dann ist die Zeit der Fortpflanzung der Wellen auf der Strecke OBA:

$$t = \frac{2H}{v_1 \cos i}, \tag{1}$$

Ausserdem

$$\Delta = 2H \operatorname{tg} i. \tag{2}$$

Indem wir i ausschalten, erhalten wir:

$$v_1 t^2 = 4H^2 + \Delta^2. \tag{3}$$

Somit haben wir in der Gleichung (3) zwei Unbekannte; folglich ist es zur Bestimmung von H prinzipiell genügend, zwei Sprengungen zu veranstalten oder eine Sprengung von zwei Seismographen registrieren zu lassen. Die mit der Gleichung(3)ausgedrückte Kurve ist eine Hyperbel, die den zweiten Zweig des Hodographen der gebrochenen Wellen berührt, und zwar den Zweig, der der reflektierenden Schicht entspricht. Als Asymptote erscheint der erste Zweig des Hodographen.

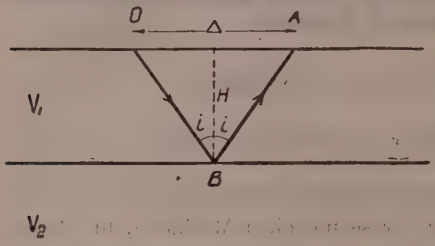


Abbildung 1.

Man muss vermerken, dass die Methode der reflektierten Wellen keine Möglichkeit für die Bestimmung von v_2 bietet, d. h. sie gibt kein Bild von der lithologischen Zusammensetzung der reflektierenden Schicht. Darum muss man bei der Arbeit nach der Methode der reflektierten Wellen wenigstens 1—2 Bohrlöcher zur Verfügung haben, nach denen man sich orientieren kann. Stehen solche nicht zur Verfügung, so genügt es 1—2 Profile nach der Methode der gebrochenen Strahlen auszuführen.

Ausserdem muss man praktisch bei der Lösung der Gleichung (3) nicht 2 sondern mehrere Punkte benutzen.

Etwas komplizierter ist die Bestimmung der Lagerungstiefe der zu erforschenden Schicht, wenn sie von mehreren Schichten mit verschiedenen physikalischen Eigenschaften überdeckt ist, d. h. von solchen an deren Scheidegrenzen die seismischen Strahlen gebrochen werden. In diesem Falle (Abb. 2) ist augenscheinlich:

$$\begin{aligned} \frac{t}{2} &= \frac{h_1}{v_1 \cos i_1} + \frac{h_2}{v_2 \cos i_2}, \\ \frac{\Delta}{2} &= h_1 \operatorname{tg} i_1 + h_2 \operatorname{tg} i_2. \end{aligned} \tag{4}$$

Ausserdem:

$$\frac{\sin i_1}{\sin i_2} = \frac{v_1}{v_2}. \tag{5}$$

Die Lösung der Gleichungen (4) ist, wenn man das Verhältnis (5) berücksichtigt, ziemlich schwierig. Aber man kann leicht zeigen, dass die Hilfsgrösse

$$v_c = \sqrt{\frac{\Delta^2 + H^2}{t^2}}, \tag{6}$$

wo $H = h_1 + h_2$ ist, für ein grösseres Intervall der Veränderungen von Δ und t konstant bleibt. Darum können die Gleichungen (4) mit einem gewissen Näherungsgrade als parametrische Gleichungen von Hyperbel betrachtet werden und man kann sie durch folgendes System ersetzen:

$$\begin{aligned} t &= \frac{2H}{v_c \cos i}, \\ \Delta &= 2H \operatorname{tg} i. \end{aligned} \tag{7}$$

Hierbei bedeuten v_c und i gewisse Parameter, die von v_1, v_2, h_1, h_2, i_1 und i_2 abhängig sind.

Die Grösse v_c kann man bedingt als mittlere Geschwindigkeit der Ausbreitung der reflektierten Wellen bezeichnen.

Schaltet man den Parameter i aus, so erhält man:

$$v_c^2 t^2 = 4H^2 + \Delta^2, \tag{8}$$

d. h. eine Formel, die der obenangeführten für zwei Schichten entspricht.

Im Sommer 1934 organisierte das Seismologische Institut zusammen mit dem Trust «Wostokneftj» eine Forschungsgruppe für seismische Versuche. Die Ausstattung der Gruppe bestand aus einem vollständigen Assortiment der oben erwähnten Vorrichtungen. Der Personenbestand wurde von Mitarbeitern des Instituts ergänzt (Gruppenführer—E. A. Koridalin, Seismologe S. I. Masarski, erster Beobachter—A. E. Ostrovskij). Als Arbeitsgebiet wurde die Naphtalagerungsstätte von Ischimbajevo in der Baschkirischen Autonomen Sozialistischen Sowjetrepublik am linken Ufer des Flusses Belaja gewählt. Die zu erforschende Schicht bildeten die Artinschen Kalksteine, die von Gipsen und Anhydriden der Kungurstufe überdeckt sind; über ihnen liegt das Lehmsandmassiv der Ablagerungen von Ufa. Die Methodik der Arbeiten war folgende: drei Seismographen wurden längs dem Profil in einer Entfernung von 50—60 m von einander aufgestellt. Längs diesem Profil wurden auch die Explosionen in Abständen von 50—100 m veranstaltet.

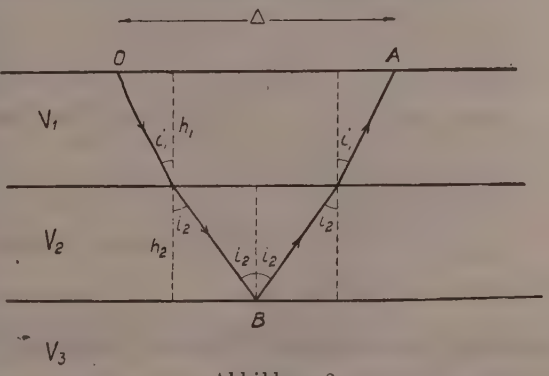


Abbildung 2.

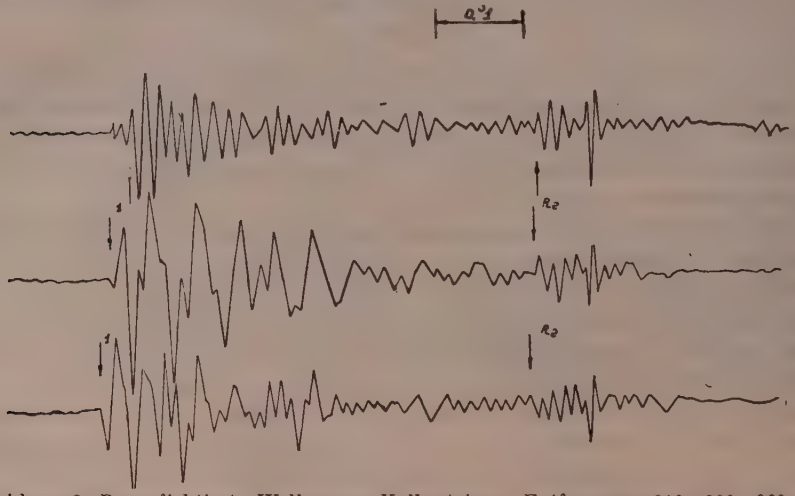
Die Methode der reflektierten Wellen wurde an 5 Profilen angewandt (2, 3, 4, 5, 6). An allen Profilen wurden reflektierte Wellen erhalten.

Die Ergebnisse der Tiefenbestimmung der reflektierenden Horizonte können in einer Tabelle (sieh S. 124) veranschaulicht werden.

An den übrigen 2 Profilen wurden die reflektierten Wellen nur von einzelnen Seismogrammen verzeichnet; dieses gab keine Möglichkeit, die Tiefe des reflektierenden Horizontes zu bestimmen.

Profil	Lagerungstiefe der Kungurdecke		Lagerungstiefe der Kalksteindecke	
	H_1 in m	Abstand vom Apparat in m	H_2 in m	Abstand vom Apparat in m
2	480	250—400	1 080	200—300
—	—	—	1 240	350—450
3	430	250—300	1 060	450—500
6	—	—	610	200—300

Die auf seismischem Wege festgestellten Lagerungstiefen der Kungurdecke und Kalksteine stimmen ganz gut mit den Ergebnissen der Bohrungsarbeiten im Arbeitsgebiet der Gruppe überein:



Abbidung 3. R_2—reflektierte Wellen von Kalkgsteinen. Entfernung—840—900—960 m.

Somit sind durch die Arbeit der Forschungsgruppe für seismische Versuche folgende Ergebnisse gewonnen. Es ist:

1) die vollständige Verwendbarkeit der Apparatur des seismologischen Instituts für die Arbeit nach der Methode der reflektierten Wellen festgestellt,

2) die Möglichkeit der Erhaltung von Reflektierungen von 2 Horizonten unter sehr komplizierten geologischen Bedingungen erwiesen,

3) die Lagerungstiefe der Artinschen Kalkgesteine in mehreren Punkten bestimmt,

4) ein neues Material für weitere Verbesserung der Apparatur gewonnen.

Seismologisches Institut.
Akademie der Wissenschaften der UdSSR.

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GEOLOGIE

ÜBER DAS VORHANDENSEIN VON ANALOGA DER PRIABONA-SCHICHTEN IN SÜD-DAGESTAN

Von I. KOROBKOV

(Vorgelegt von V. Obručev, Mitglied der Akademie, d. 11. VI. 1935)

Im Durchschnitt der Paläogenablagerungen am Fluss Rubas-Tschai ist die von mir festgestellte Zone mit *Variamussium fallax* Korob. (4) von Gesteinen unterlagert, die einen eigentümlichen Komplex der Molluskenfauna einschliessen. Diese Gesteine können ihrer lithologischen Zusammensetzung nach in fünf Gruppen gegliedert werden.

1. Mergel—braun in feuchtem Zustand, grau beim Austrocknen, mit der Molluskenfauna der unteren Abteilung der Zone; unter diesen Mollusken hat man einige Gastropoden gefunden, die in der Zone nicht vorkommen.

2. Grauer Mergel, etwas bläulich, mit Muschelbruchstücken von *Spondylus* und *C lamys.*

3. Grünlicher und grauer Mergel—dicht, klingend, mit grossen Foraminiferen und sehr selten vorkommenden Molluskenmuscheln.

4. Mergel—braun in feuchtem Zustand und grau, wenn ausgetrocknet, tonig, stellenweise sandig, weniger dicht als die höher und tiefer liegenden, Gesteine mit einer grossen Menge gut erhaltener Mollusken, unter denen Schalen von *Spondylus* und *Vasconella* vorwiegen.

5. Mergel—grau und hellgrau an der Oberfläche, bläulich oder grünlich im Bruch, dicht, hart, dickschichtig, mit seltenen kleinen Muscheln von *Vulsella*, *Dimya*, *Anomya.*

Die gesamte Mächtigkeit der beschriebenen Gesteine beträgt 36 m.

Da diese Gesteine sich von den höher und tiefer gelagerten durch ihre lithologische Zusammensetzung und durch einen abweichenden Komplex der Molluskenarten unterscheiden, so habe ich sie in einen selbständigen Horizont ausgeschieden und, demselben infolge der für ihn charakteristischen grossen Menge von Muscheln verschiedener Spondylus-Arten, den Namen Spondylus-Horizont gegeben (3). Die untere Grenze des Spondylus-Horizontes wird durch eine Schicht von konglomeratartigem 0.15—0.45 m mächtigem Sandstein gebildet, den sehr veränderte Gesteine des Kuma-Horizontes (Schichten mit *Lyrolepis caucasica* Rom.) unterlagern. In den Gesteinen

des Spondylus-Horizontes sind folgende bis auf die Art bestimmte Mollusken angetroffen worden:

1) *Spondylus buchi* Phil.,
2) *Spondylus bifrons* Münster in Goldfuss,
3) *Spondylus cisalpinus* Brongn.,
4) *Spondylus radula* Lam.,
5) *Chlamys biarritzensis* d'Arch.,
6) *Pseudamussium corneum* Sow.,
7) *Variamussium fallax* Korob.,
8) *Pycnodonta brongniarti* Bronn.,
9) *Vasconella grandis* Bellardi,
10) *Crassatella fuchsi* Slod.,
11) *Dentalium haeringense* Dreger,
12) *Dentalium martini* Boussac,
13) *Cerithium dregeri* Boussac,
14) *Aturia ziczac* Sow.

Indem ich mir das Recht vorbehalte eine eingehende Beschreibung der aufgezählten Arten und deren Abbildungen in einer speziellen Monographie zu geben, will ich mich hier nur auf die Analyse ihrer stratigraphischen Verbreitung beschränken.

Von der Gesamtzahl der angeführten Arten sind fünf derselben der Zone mit *Variamussium fallax* Korob. und dem Spondylus-Horizont gemeinsam. Es handelt sich um folgende Arten:

1) *Pseudamussium corneum* Sow.,
2) *Variamussium fallax* Korob.,
3) *Dentalium haeringense* Dreger,
4) *Cerithium dregeri* Boussac,
5) *Aturia ziczac* Sow.

Von *Pseudamussium corneum* Sow. ist in den Gesteinen dieser Zone nur ein einziges Exemplar gefunden worden, während diese Art im Spondylus-Horizont sehr verbreitet ist. Die anderen vier Arten kommen, im Gegenteil, im Spondylus-Horizont in geringer Zahl von Individuen vor, während sie für die Zone wegen ihrer grossen Verbreitung als Leitfossilien betrachtet werden können. *Pseudamussium corneum* Sow. und *Aturia ziczac* Sow. sind Arten von grosser vertikaler Verbreitung. Sie sind vom unteren Eozän bis zum mittleren Oligozän bekannt. *Variamussium fallax* Korob., *Dentalium haeringense* Dreger und *Cerithium dregeri* Boussac sind Unteroligozänarten, die ausser dieser Zone, deren Zugehörigkeit dem unteren Oligozän durch eine Reihe von Tatsachen bewiesen ist (4), auch in ihren westeuropäischen Analoga bekannt sind. *Variamussium fallax* Korob. ist in dem Kleinzeller-Tegel, im nord-westlichen Ungarn und in den Häringer-Schichten von Tyrol angetroffen worden; *Dentalium haeringense* Dreger —in den Häringer-Schichten und den Schichten von Reut im Winkel; *Cerithium dregeri* Boussac —nur in den Häringer-Schichten (7).

Die stratigraphische Verbreitung der bis auf die Art bestimmten Mollusken ist in folgender Tabelle angeführt.

Arten	Unter-Eozän	Mittel-Eozän	Ober-Eozän	Unter-Oligozän	Mittel-Oligozän
1. *Spondylus buchi* Phil.			+	+	
2. *Spondylus bifrons* Münster in Goldfuss			+		
3. *Spondylus cisalpinus* Brongn.			+	+	+
4. *Spondylus radula* Lam	+	+	+		
5. *Chlamys biarritzensis* d'Arch.			+	+	
6. *Pseudamussium corneum* Sow.	+	+	+	+	+
7. *Variamussium fallax* Korob.				+	
8. *Pycnodonta brongniarti* Bronn			+	+	
9. *Vasconella grandis* Bellardi		+	+		
10. *Crassatella fuchsi* Slod.			+		
11. *Dentalium haeringense* Dreger				+	
12. *Dentalium martini* Boussac			+		
13. *Cerithium dregeri* Boussac				+	
14. *Aturia ziczac* Sow.		+	+	+	+
	2	4	11	9	3

Wie aus der Tabelle ersichtlich, besteht die Molluskenfauna des Spondylus-Horizontes aus verschiedenartig verbreiteten Arten: 2 Arten von grosser vertikaler Verbreitung; 3 Arten, die nur aus dem oberen Eozän bekannt sind; 1 Art, die dem mittleren und oberen Eozän gemeinsam ist; 4 Arten, die aus dem oberen, sowohl wie aus dem unteren Oligozän bekannt sind; 1 Art, die dem oberen, dem unteren und dem mittleren Oligozän gemeinsam ist, und aus 3 Unteroligozänarten. Dieser eingentümliche Komplex der Molluskenarten ist für die allerobersten Teile des Eozäns charakteristisch, die von den Forschern des Paläogens der Alpen die Bezeichnung Priabona-Schichten erhalten haben, und deren Fauna von Oppenheim erforscht und beschrieben worden ist (6). In der Tat schliesst die Molluskenfauna des Spondylus-Horizontes 9 Arten ein, deren Vorhandensein charakteristisch für die Priabona-Schichten ist, wo sie in grosser Zahl von Individuen vorkommen. Die Anwesenheit in der Fauna des Spondylus-Horizontes von 70% der für die Priabona-Schichten charakteristischen Arten kann gewiss nicht als eine zufällige Erscheinung betrachtet werden. Augenscheinlich ist der Spondylus-Horizont ein Analogon der Priabona-Schichten. Die Richtigkeit einer solchen Vermutung wird von einer Reihe von Daten bestätigt, die meines Erachtens genügend überzeugend sind. Auffallend ist, zum Beispiel, der Umstand, dass die für die Priabona-Schichten charakteristischen Arten im Spondylus-Horizont durch eine grössere Zahl von Individuen vertreten sind, als diejenigen, die in den angeführten Schichten nicht vorkommen. Die im Spondylus-Horizont am häufigsten vorkommende Art ist *Vasconella grandis* Bellardi; dann folgt *Spondylus buchi* Phil., *Pseudamussium corneum* Sow.,

Spondylus cisalpinus Brongn., *Pycnodonta brongniarti* Bronn. u. a. Die stratigraphische Lage des Spondylus-Horizontes bestätigt seine Zugehörigkeit zum allerobersten Teil des Eozäns. Wie schon erwähnt, befindet sich im Hangenden des Spondylus-Horizontes die Zone mit *Variamussium fallax* Korob., die dem unteren Oligozän angehört, während das Liegende desselben von einer Schicht konglomeratartigen Sandsteins gebildet wird, unter dem die veränderten Gesteine der Schichten mit *Lyrolepis caucasica* Rom. gelagert sind. In diesen Gesteinen hat W. D. Golubjatnikow eine Mollusken- und Foraminiferenfauna entdeckt, welche von W. S. Slodkewitsch und B. F. Meffert bearbeitet worden ist, die sich für die Zugehörigkeit dieser Fauna dem Oberoligozän-Alter ausgesprochen haben (2). In dem westlichen Teil des Kachetischen Bergrükens ist auch von Wassojewitsch eine Fauna von grossen Foraminiferen in den Schichten mit *Lyrolepis* angetroffen worden, die von Professor F. Bieda (Universität Krakau) bearbeitet und dem oberen Eozän zugerechnet worden ist (1). Beachtenswert ist der Vergleich der Fauna des Spondylus-Horizontes mit der Fauna der Kiew-Stufe des Südens von UdSSR. Wir haben hier folgende sechs, beiden gemeinsame Arten: 1) *Spondylus buchi* Phil., 2) *Sp. bifrons* Münster im Goldfuss, 3) *Sp. radula* Lam., 4) *Chlamys biarritzensis* d'Arch., 5) *Pseudamussium corneum* Sow., 6) *Crassatella fuchsi* Slod. Die aufgezählten Mollusken, besonders die Spondylus-Arten und *Pseudamussium corneum* Sow., sind Leitfossilien für die Kiew-Stufe. Das geologische Alter der Kiew-Stufe wird als Obereozän bestimmt und von manchen Forschern wird diese Stufe als Analogon der Priabona-Schichten angesehen. Die Fauna des Spondylus-Horizontes hat eine gewisse Ähnlichkeit mit der Fauna des «Agwi-Horizontes», der von B. F. Meffert in dem Letschhumy Rayon in Transkaukasien ausgeschieden worden ist. Dem Alter nach gehört der «Agwi-Horizont» auch dem Oberoligozän an (5).

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GENETICS

DEVIATIONS FROM HARDY'S FORMULA IN PARTIAL ISOLATION

By A. KOLMOGOROV

(Communicated by S. Bernstein, Member of the Akademy, 18. VI. 1935)

R. A. Fisher's and S. Wright's mathematical researches (1) refer to the evolution of the gene's concentration in a population where free crossing is prevalent. The aim of the present work is to indicate that method which would enable us to obtain analogous results in a population disintegrating into partial feebly connected populations. The following scheme has been subjected to a mathematical analysis: a population with a constant number of specimens N disintegrates into s partial populations containing n specimens each ($N=sn$); free crossing over occurs in each partial population; in addition to this every generation of each population gives on an average k «roving» specimens; the «roving» specimens, independently of their origin, accidentally join same partial population where they participate in producing the following generation. N. P. Dubinin and D. D. Romašov pointed out this scheme as one of the suitable ones. A series of equally interesting schemes of limited crossing do not submit, so far, to any mathematic process of treatment.

1. Instance of absence of selection. We shall designate by $\bar{p}$ the concentration of a certain gene in the large population and by p the concentration of the same gene in the partial population. We presuppose in the present section that the gene under observation has not been subjected to selection. The formulae presented below are asymptotic formulae, correct in the case when $n\bar{p}$, $\frac{n}{k^2}$, and s leads to infinity. Should the values $n\bar{p}$, $\frac{n}{k^2}$, and s prove of sufficient magnitude, they may practically be applicated.

The increase of the p concentration in one generation of a certain partial population we shall designate by Δp. In accordance with R. A. Fischer and

S. Wright we hold that for the average value of Δp and $(\Delta p)^2$ the following formulae must prove correct:

$$A = E(\Delta p) = \frac{k}{n}(\bar{p} - p),$$

$$B = E(\Delta p)^2 = \frac{pq}{2n}, \quad q = 1 - p.$$

Owing to the magnitude of s, the change in the total concentration $\bar{p}$ will proceed more slowly than those of the partial concentration p. We are thus enabled to temporarily accept the concentration $\bar{p}$ as constant. The concentrations p in partial populations will deviate from $\bar{p}$ this and that way. After a certain lapse of time the oscillations of p around $\bar{p}$ will lead to the stationary distribution of probabilities for the concentration p. This stationary distribution $u(p)$ answers to the differential equation

$$\frac{1}{2}\frac{\partial^2}{\partial p^2}(Bu) - \frac{\partial}{\partial p}(Au) = 0.$$

Hence, we obtain:

$$u(p) = \frac{p^{4k\bar{p}-1}\, q^{4k\bar{q}-1}}{B(4k\bar{p},\ 4k\bar{q})}. \tag{1}$$

S. Wright obtained formula (1) by a different method. It is possible to prove that (1) not only presents the distribution of probabilities in the concentration p but that, given a sufficiently large number s of partial populations, the distribution of partial populations along p concentrations, observed by us, will be also presented by formula (1).

In this case Hardy's formula is realized in every partial population, i. e. the concentrations of specimens of the AA, Aa, and aa type are equal to q^2, $2pq$, and p^2. Concentrations of specimens of the AA, Aa, aa type in the large population can therefore be computed according to the following formulae:

$$\overline{AA} = \int_0^1 q^2 u(p)\, dp,$$

$$\overline{Aa} = 2\int_0^1 pq\, u(p)\, dp,$$

$$\overline{aa} = \int_0^1 p^2 u(p)\, dp.$$

When worked out we obtain:

$$\begin{aligned} \overline{AA} &= \frac{4k}{4k+1}\bar{q}^2 + \frac{1}{4k+1}\bar{q}, \\ \overline{Aa} &= 2\frac{4k}{4k+1}\bar{p}\,\bar{q}, \\ \overline{aa} &= \frac{4k}{4k+1}\bar{p}^2 + \frac{1}{4k+1}\bar{p}. \end{aligned} \tag{2}$$

Formula (2) gives a solution to the problem expressed in the title of the present paper.

In view of the absence of selection the average value $E(\Delta\bar{p})$ of increase of the gene's total concentration in one generation of the large population is equal to zero, whereas the intensity of the accidental variations of concentration in the large population is expressed by $E(\Delta\bar{p})^2$. The latter is computed the following way:

$$E(\Delta\bar{p})^2 = \frac{1}{s}\int_0^1 E(\Delta p)^2 u(p)\,dp = \frac{1}{2sn}\int_0^1 pq\,u(p)\,dp.$$

The result is:

$$E(\Delta\bar{p})^2 = \frac{4k}{4k+1}\,\frac{\bar{p}\,\bar{q}}{2N}. \tag{3}$$

According to R. A. Fischer and S. Wright, in the instance of free crossing we should obtain

$$E(\Delta\bar{p})^2 = \frac{\bar{p}\,\bar{q}}{2N}.$$

2. Effect of selection. Formula (1), Hardy's formula for partial populations, and formula (2), which in large populations is its substitute, all retain their significance in the presence of selection if the coefficient of selection α is considerably lower than $\frac{1}{n}$. We shall consider the latter case; thus, the formulae presented below are nothing but asymptotic formulae correct in the case when $n\alpha$ leads to zero. The instance of a recessive gene is of special interest, as then the increase of the gene's concentration, called forth by selection, is equal on the average $\alpha p^2 q$ in each partial population. For the total concentration we, therefore, have:

$$E(\Delta\bar{p}) = \alpha\int_0^1 p^2 q\,u(p)\,dp,$$

or

$$E(\Delta\bar{p}) = \alpha\,\frac{4k}{(4k+2)(4k+1)}\,\bar{p}\,\bar{q}\,(4k\bar{p}+1). \tag{4}$$

Formula (4) may be taken into account to confirm (in the instance of the scheme under our observation) the general statement of the existence of the optimum of partial isolation for the selection of recessive genes, a statement propounded and qualitatively proved by A.A. Malinovskij. To calculate at

which value of k selection proceeds the fastest, presents no difficulty. With small concentrations of $\bar{p}$ this optimum value of k is equal to

$$k_0 = \frac{1}{4}\sqrt{2} = 0.35.$$

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PALAEOBOTANY

THE MIOCENE SEED-FLORA NEAR THE TOWN OF TOMSK (SIBERIA)

By P. NIKITIN

(Communicated by A. Borissiak, Member of the Academy, 7. VI. 1935)

There exists in Siberia a widely-developed Tertiary continental series abounding in vegetable remains. The age of some of its horizons is variously determined by various authors. Thus, the Tertiary sediments of the right bank of the river Tom near the town of Tomsk were classed by Yanischevski (1) in 1915 as belonging to the Miocene on the strength of the prints of 14 forms of arboreal plants he had identified. In 1931, Khakhlov (2) referred the same series to the upper Eocene or to the lower Oligocene, while Krishtofovich (3) classed it in 1933 as upper Oligocene or lower Miocene. In 1934, Sukachov (4) determined from the pollen 10 forms (the determinations being merely generic ones), which gave a complex essentially differing from that of Yanischevski. Similar pollen floras from Vasugan river Sukachov is inclined to regard as «probably Pliocene, but possibly Miocene». In 1935, he makes a more definite statement, being inclined to class that pollen flora as «Pliocene preserved there since the Miocene epoch» (5).

Consequently, in the opinion of modern palaeobotanists, the age of Tertiary sediments around Tomsk is determined as either 1) Eocene, or 2) Oligocene, or 3) Miocene, or 4) Pliocene. This wide range of conjecture is no doubt due not only to the difference of opinion on the rapidity of migrations, but also to the scarcity of factual data. The object of this paper is to supply the lacking facts.

In the autumn of 1934, I succeeded in isolating from the Tertiary series investigated by Yanishevski and Sukachov some fossil seeds and fruits. They were collected at the base of the series, at four different points along a horizontal line about 1 kilometre in extent. The fossil-bearing rocks were: the brown clay, kaolinized downwards, overlying carbonaceous shales; 2) the lignite (brown coal) overlying the clay, 3 and 4) sands containing arboreal remains and replacing the lignite on some horizons. All the four points yielded floras similar to one another as to age and geography.

A preliminary estimate of the percentages of various ecological forms of the floras yielded by these four points has given the following results:

Table 1

The Ecological Indexes of the Four Seed-Floras near the Town of Tomsk

	Under clay	Over brown coal	Adjoining sands	
	1	2	3	4
Percentages of aquatic plants . .	25	20	21	23.5
Semi-aquatic plants	75	55	42	41
Meadow plants	0	5	16	12
Woody plants	0	20	21	23.5

Hence, the lower brown clay may be regarded as the mud of a calm and shallow lake surrounded by marshy banks, there having been no influx from outside. Judging from available data, the overlying lignite owes its existence to the swampy forests which sprang up on the site of the lake. The sands adjoining the lignite have no doubt been deposited by sluggish streams which crossed the marshy forest grounds.

No less than 70—80 forms have been identified in the four floras. The list given below shows the forms that have been more or less accurately identified (the forms identified down to species are published for the first time in the USSR).

Salvinia auriculata var.
Azolla cf. *pinnata*
Selaginella sp.
Coniferae 2 spp.
Typha 2 spp.
Potamogeton globosus P. A. N.?
Sagittaria sp. nov.
Alisma sp.
Epipremnum crassum Reid (var?)
Epipremnites menispermoides nov. gen.
Sparganium ramosum var.
S. cf. *noduliferum* Reid var.
S. sp.
Carex spp.
Cyperus sp.
Gpamineae
Spirematospermum nov. gen?
Brasenia tuberculata Reid
B. sp.
Nuphar cf. *canaliculatum* Reid
Aldrovanda eleanorae P. A. N.
Decodon globosus (Reid) P. A. N.
D. gibbosus Reid
cf. Diclidocarya menzeli Reid
Vitaceae spp.
Actinidia sp.
Meliosma sp.?
Hypericum pliocenicum P. A. N.
Menyanthes parvula sp. nov.
Sambucus pulchella Reid?
Rubus spp.
Potentilla sp.?
Euphorbia sp.?
Chenopodium sp. nov.
Proserpinaca reticulata Reid
Lysimachia subthyrsiflora P. A. N.
Ulmaceae
Carpolithus rosenkjaerii Hartz.
Carpolithi spp.

Notes. 1) With the exception of *Decodon* (7), the initials P. A. N. refer to species described in the writer's MS. on the Pliocene floras of the Don glaciation zone. The name of Reid is quoted in connection with the species described by C. and E. M. Reid, or by E. M. Reid, for the Pliocene of Western Europa (8,9). The abbreviation «nov.» denotes that the genus or species in question has not yet been described.

Salvinia auriculata in the macrospores is, as far as I know, mentioned herein for the first time as a fossil.

Azolla cf. *pinnata* belongs to the section of southern (not Norht American) azollae. Is known to occur in the Pliocene of Western Europe.

Spirematospermum (order Zingiberaceae) of Tomsk is represented by a form intermediate between the Eocene-Miocene *S. Wetzleri* chandl. and the *S. chandleri* P. A. N. of the Voronezh Pliocene.

The combined presence of two species of *Decodon* and of the genus *Diclidocarya* is characteristic of the Seftenberg Miocene.

Vitaceae and *Actinidia*: the determinations are beyond doubt.

Menyanthes parvula: the first find of a new species of this genus, which had so far been regarded as monotypic. The Voronezh Pliocene contains a typical *M. trifoliata*.

Carpolithi spp: under this heading have been classed the seeds and fruits of numerous species unknown to me and which it is impossible to study under Tomsk conditions.

The following table gives a comparison of the percentages of exotic and extinct species contained in each of the seed-floras of different age.

Table 2

The Relationships of Four Seed-Floras

	Tomsk	Pont-de-Gail (Mio-Pliocene)	Reuver (Lower Pliocene)	Voronezh (Lower Middle Pliocene)
Percentages of exotic species . . .	100	92	88	70
Percentages of extinct plants . .	80—90	61	30	19—25

In determining the age of the Tomsk flora, the writer was guided by the following considerations:

1) The presence of numerous Pliocene forms of Western and Eastern Europe points to the proximity of our flora to the Pliocene in point of age. Still, it must be kept in mind that the preponderance of Pliocene forms in the preliminary list for Tomsk is partly due to the presence of numerous forms that have not yet been identified and most of which are obviously other than Pliocene.

2) The flora shows a total absence of present-day Tomsk species; Pliocene, being characterised by 1—60 p. c. of local species, is therefore ruled out.

3) According to preliminary estimate the flora is composed of not less than 80—90 p. c. extinct species. In the seed-floras of both Western and Eastern Europe, their percentages range between 8 p. c. (Tegelen) and 30 p. c. (Reuver), being as high as 61 p. c. in the Mio-Pliocene flora of Pont-de-Gail. Hence—a greater antiquity of the Tomsk flora as compared with even the Pliocene.

4) Here the preservation of seeds and fruits is inferior to that of the Pliocene floras of Voronezh, the Tomsk fossils being more xylenized.

5) The Tomsk preliminary list does not contain any typical representatives of the Oligocene.

The above features would determine the age of the fossil seed-flora of Tomsk as apporaching the Mio-Pliocene, but older than the latter, while younger than the Oligocene, i. e. as Miocene. At the same time, the abundance of Pliocene forms contained therein would seem to confirm the migrational theory of Prof. Krishtofovich.

As regards the climate of Tomsk in the Miocene period the remains found would seem to indicate that it was considerably milder than its present-day climate, without, however, being subtropical. Presumably, it was not unlike the present-day climate of Primorskaya Region, of China, Japan, or the Maritime States of the USA, i. e. similar to the Pliocene climate of Western Europe. The utter absence in the flora of evergreen forest forms of even the Mediterranean type would point, however, to a greater continentality of the Miocene of Western Siberia as compared with even the Pliocene of Europe.

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ZOOLOGY

RECAPITULATION: MORPHOLOGICAL AND HISTOLOGICAL

By A. Severcov, Member of the Academy

The purpose of the present communication is to show that the basic methods of investigating phylogenesis are to the same degree applicable to histology as to morphology: in other words, that recapitulation, in the meaning of the biogenetic law of Muller-Heckel, holds in the same measure in the histological development of tissues as in the ontogenetic development of organs.

In a number of my preceding works I have been able, on the basis of a whole series of investigations especially devoted to this subject, to work out a theory which I called the «theory of phylembryogenesis, that is, of evolution by means of change of progress of embryonic development». Owing to these investigations, ten more means or modes of phylogenetic changes have been added to the two that were worked out by F. Muller in his time. Most of these additions have been established by myself and my pupil and nearest fellow worker B. C. Matvejev, a part by certain West-European scientists, V. Franz, A. Neff, and de Beer.

The theory of phylembryogenesis, as is well known, presumes, that hereditary changes in animals take place in various stages of individual development, but that changes, that take place at the different stages of the individual development, have, in the progress of this development, different significance. Thus, during anabolism, that is, during embryonic changes taking place through addition of new stages of development at, the termination of the morphogenesis, there occurs a c o m p l e t e r e c a p i t u l a t i o n of the last stages of morphogenesis (that is, stages quite near to the adult state) of the succesive series of ancestors. In deviation during the middle stages of morphogenesis, there takes place only a certain recapitulation of ancestral embryonic characters.

Let us see, now, in what degree this histogenetic recapitulation exists, or, in other words, to what degree, in the course of the histogenetic development of any particular tissue of a present-day adult animal, traits appear which would be characteristic for the specialized cells of the given tissue in the ancestors of this animal.

Inasmuch as the histological structure of extinct animals is at the present time but little known to us, we are compelled to use the data of comparative histology and comparative histogenesis—that is to say, to compare the histogenesis of specialized elements of the tissues of one or another group of higher animals, for example, the higher vertebrates, with the structure of the same tissues in the lower forms which are near to the ancestors of the given higher group. Unfortunately, our knowledge of the phylogenesis and comparative histogenesis of tissues is also, as yet, extremely unsatisfactory; consequently, the examples we are able to bring forward here are very few. However, I think that further study of the histogenesis of animals will give us a much greater number of them. At present we are able to cite as examples the histogenesis of epithelial cells, of the blood, of the unipolar nerve cells and of the tissues of the electric organs of certain skates (Torpedo, Raja).

In studying the development of the skin of the higher vertebrates, for example, of man, we see that in the early stages of ontogenesis the epidermis of the human embryo consists of one-layered cylindrical epithelium, which through cell division in later stages of development is converted at first into a two-layered and then into a many-layered homogeneous epithelium of the embryo; in the course of further development there takes place a change of the histological structure of the surface layer of the epidermis: the cells flatten and becoming corneous, lose their nuclei. In the adult we have a many-layered specialized epidermis, consisting of a number of fully differentiated layers: stratum corneum, stratum lucidum, stratum granulosum, and stratum Malpigii.

The question arises before us, whether the different stages of the histogenesis of the epidermis is a recapitulation of the characters characteristic for the ancestors of man. In order to answer this question—in the absence of the paleohistological data—we must turn to the structure of the epithelial tissue of a number of primitive relatives of the higher vertebrates. On doing this we find that the lancelet in the adult stage has a one-layered epidermis. We may suppose that there occurs here a histogenetical recapitulation, a repetition in the histogenesis of a higher mammal of the one-layered epithelium which is characteristic of very distant acranial ancestors of the higher vertebrates. We may compare the stage of histogenetic development of the epidermis, when the one-layered epidermis is transformed into a many-layered without cornification of the cells of the superficial layer, with the epidermal structure of the bony fishes, which consist of many layers of cambial, that is, undifferentiated, epidermal cells. Here can be seen a recapitulation of the structure of the epidermis of the fish-stage ancestors of mammals. The stage of beginning cornification of the superficial layer is to be found in the skin of the *Salamandra maculosa*: here apparently there is a recapitulation of the epidermal structure of the amphibian ancestors of the mammals.

Thus, with a conciderable degree of probability we may suppose that the epithelial covering of the body of mammals has passed, in its phylogenesis,

successively through the stage of undifferentiated single-layered epithelium, the stage of undifferentiated many-layered epithelium, the stage of many-layered epithelium with a simple structure of the superficial corneous layer, and, finally, into the stage of the complex epithelial structure of the higher vertebrates.

Besides this we must note that the recapitulation of ancestral characters concerns not only the inter-relations of the cells of a given tissue, but also the form and structure of the epithelial cells themselves.

We have an extraordinarily interesting example of histogenetic recapitulation, one taking place in isolated cells,—the red blood corpuscles of mammals.

As is known, in the majority of mammals, including man, the red blood corpuscles are distinguished essentially by two traits, namely, the accumulation of haemoglobin in the plasm and the loss of the cell nuclei; furthermore these traits appear in a definite order of development: at first there accumulates haemoglobin in the body of the undifferentiated cell, and then the nucleus disappears. If we compare the histogenesis of the erythrocytes of the higher mammals with that of the lower vertebrates, we see that the presence of a nucleus in the early stages of the histogenesis and its loss in the last stages is a histogenetic recapitulation of the phylogenetic development of the blood of the higher mammals. The same may, in all probability, also be said of the development of haemoglobin in the blood, the haemoglobin pigment having appeared in the erythrocytes of the vertebrates long before the nucleus has disappeared. Thus, in the most ancient cranial vertebrates, that is, in the *Cyclostomata* and shark-like fishes, the erythrocytes already contain haemoglobin: in lancelet the blood is yet colourless; thus, the formation of haemoglobin took place during the transformation of the acranial ancestors of the vertebrates into protocraniates, that is, back in the pre-Silurian epoch.

We can observe a typical histogenetical recapitulation of ancestral traits if we study the formation of the unipolar nerve cells in the cranial and spino-cerebral ganglia of the embryos of all the higher vertebrates. As is known, these unipolar nerve cells develop from typically bipolar ganglionic cells. One can plainly see that in the spinal roots of the segmental nerves of the lancelet the spino-cerebral ganglia consist of typical bipolar ganglionic cells, precisely like those in spino-cerebral ganglia of the embryos of the higher vertebrate animals. In some of the shark-like fishes, we likewise have typical bipolar cells in the spino-cerebral ganglia, essentially just like the cells in the spinal roots of the lancelet. In the bony fishes a few unipolar cells are already found in the spino-cerebral ganglia, along with a great preponderance of bipolar cells, and it is only in the higher forms that the bipolar cells entirely disappear. All this shows us that the transformation of the bipolar ganglionic cells into unipolar ones took place in phylogenesis very slowly and gradually.

Finally, the histogenesis of the pseudo-electric and electric organs of the skates (Torpedo, Raja) presents a typical recapitulation of the evolution of these forms.

All the facts that we have set forth are known both to morphologists and to histologists, but the latter have, up till the present time, devoted little attention to their phylogenetic significance, which we especially want to emphasize here.

These few examples of histogenetic recapitulation of quite different tissues (epithelium, blood, nervous system, the tissue of electric organs) show, first of all, that recapitulation of the traits of the tissue structure of ancestors actually exists in the ontogenesis (histogenesis) of their descendants; and, secondly, that the order of this histogenetic recapitulation is the same as in the recapitulation of the traits of organs, that is, in morphological recapitulation, namely, that the traits of distant ancestors are met in the early stages of the histogenesis of the descendants, while those of near ancestors are met with in the late stages of the histogenesis of the descendants. Thus, here in ontogenesis, there are repeated not only ancestral traits but also the order of their appearance in phylogenesis.

The ancestral traits are those out of which is developed the definitive structure of the cells of a given tissue. Such ancestral traits are, for example, the bipolar structure of the ganglionic cells of the spino-cerebral plexi, out of which the unipolar structure of these cells develops in the higher vertebrates; the structure of the club-shaped cells of the electric organs, which make up the electric plates; the nucleate cells in the blood-forming organs, out of which the non-nucleate corpuscles of the higher mammals develop; the one-layered epithelium of the embryos of mammals, which gives origin to the many-layered epidermis of the adult form.

All these ancestral stages are stages that are necessary for the development of higher forms of tissue. We are led to think that the evolution of the histogenesis of tissues at times went according to the type encountered in the evolution of organs, viz., a piecing-on of stages, or anabolism, with this difference, that here the piecing-on takes place not in groups of embryonic cells, but in the cells themselves, and at times as a deviation; in both cases, histogenesis, in its means of evolution, fully corresponds to embryogenesis and is its quite natural conclusion.

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ZOOLOGY

SEPTICAEMIA OF BEES AND ITS CAUSATIVE AGENT

By A. BOIKO

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In the summer of 1934 there broke out at many apiaries of the southern regions of the Ukraine (Grosulovski, Molochanski, Kirovski, Krivorozhski, Zaporozhski, Nikopolski, Kakhovski, Chistiakovski, and others) an epizoötic among adult bees.

The bee colonies stricken with this epizoötic were so weakened that they could not gather sufficient supplies of honey for the winter. Many colonies perished completely, having lost all their adult population.

This epizoötic disease in most cases showed a wavelike curve, dying down for a time and then breaking out again with renewed force and carrying away each time about 20 per cent of the adult population of the diseased bee colony.

The clinic symptoms of the diseased bees consisted in a loss of their flying powers and in a rapid onset of death without any intestinal disorders.

Examinations of a large number of corpses of bees from bee colonies, infected with this disease, for the presence of the causative agents of all the diseases of adult bees as yet known in the USSR, as Nosema disease, Acarine disease, paratyphoid, gave negative results.

Outbreaks of epizoötics causing great losses to the bee-keeping industry and similar in their clinic symptoms, their course, and other features, to the one under discussion, have already been long known from literature to exist among the adult bees, mainly at apiaries of the South of the USSR. But their occurrence was ascribed to various non-infectious causes, and their nature remained in essence unknown. This was the reason, that impelled us to devote ourselves to elucidating the true cause of the epizoötic of 1934.

The post-mortem changes in all the preserved and unpreserved bees were peculiar. The corpses very easily separated into parts: head, thorax, abdomen; the legs broke up into their separate segments; the hairs covering the chitin layer came off if slightly touched. The muscles of the thorax appeared as a putrid mass half filling the thorax cavity. The colour of this putrid mass was brown of different shades, sometimes almost black. In the initial

stages of the disease, the decomposed muscles appear as a mass of brown detritus. The corpses emitted a pungent putrid odour. Microscopical examinations of this detrital and putrid mass showed it to contain an enormous quantity of microorganisms of 1—2 species.

The feeding of a suspension of these decomposed muscles to bees under experimental conditions led to a 100 per cent mortality in the laboratory bee-hive during a period of 10 days. Post-mortem changes in bees that died during these experiments were identical to those in bees that were infected and died under natural conditions, but in the majority of cases a pure culture of one species of bacterium was isolated from the haemolymph of all the organs of the corpse.

In subsequent experiments, carried out in 3 series of tests on more than 800 bees, this pure culture caused after one feeding a 45—100 per cent mortality among bees of the laboratory hives during 10 days. The maximum mortality was observed between the 3rd and the 7th days. The post-mortem changes were the same, i. e. putrid decomposition of the tissues. A pure culture of this bacterium was to be found in all the soft tissues of the corpse. Examinations of sick but still comparatively lively bees presented a microscopic picture of sepsis of the haemolymph and tissues caused by this bacterium.

The culture of this bacterium was thoroughly studied and then determined after Bergey.

The following characteristics were established.

The bacterium is rod-shaped with rounded ends; its length is 0.8—1.2 microns in agar cultures and 1.0—1.5—2.0 microns in bouillon ones; its thickness is 0.7—0.8 microns. It is actively motile and has two flagella at one of its poles; diplobacteria are sometimes to be observed in bouillon; has no capsule and no spores; in 20 day old bouillon cultures a decrease in length to a coccus is to be observed. It is often to be found in corpses in such a form. The usual aniline dyes stain it very well. It is gram-negative.

It grows well in the usual nutrient media (pH 7.2—7.4) at 20° C, but still better at 37° C in aerobic and anaerobic conditions. It gives an even turbidity in bouillon with the formation of a light precipitate after the third day. No film was to be observed. Well developed colonies on agar attain a diameter of 0.5 cm; they are oval, somewhat convex, sharply delineated, with even edges, dull opal-coloured in the centre, clear on the periphery, of an oily appearance; they are easily washed off by physiological solutions; no formation of ridges was observed; but in colonies that are drying up there first appears a ring on the periphery, then the edges of the colony become more or less deeply fringed, and a clearly granular structure may be observed inside the colony. Fresh agar cultures opalesce in the passing light and produce no pigment. Later on this opalescence disappears. On agar the culture assumes a dull greenish hue and has an oily surface. In gelatine plates the colonies are similar, but with a deep centre of liquefaction.

Puncture gelatine cultures at 15° C liquefy the gelatine funnellike the whole length of the puncture with the formation of a gas bubble at the top. At such a temperature the whole gelatine liquefies in 4 days, and at 20—22° C in 2—3 days. On liver agar, a very exuberant growth is obtained; a good growth is also obtained on agar with glycerine; on Endo's agar, the colonies assume a red tint, but the medium itself does not change.

Raised, well noticeable, oily colonies are obtained on potato; they gradually grow darker, assuming first a brown and then an almost black colour; the potato itself also turns dark brown.

Cultures on all protein cultures, especially on solid ones, emit a pungent, unpleasant, putrid odour.

Milk curdles on the second day into a clot, and then there occurs a comparatively intense peptonization, which dissolves half the clot by the 3rd day; milk with litmus on the second day changes its blue colour to dirty lilac, and on the third to dirty pink; the peptonized layer loses its colour (reduction). Molke litmus (after Petruschky) becomes intensely pink on the second day, and on the sixth resumes its initial blue colour formation of acid with a subsequent accumulation of alkali). It produces hydrogen sulphide in peptone water. Both the Morelli and the Salkowski tests for indol are negative.

It decomposes glucose, levulose, saccharose, maltose, mannitol, xylose (a very slight decomposition and hardly noticeable bubble of gas in this last) with the formation of acid and a very insignificant quantity of gas, and with a subsequent accumulation of alkali. It decomposes fructose, galactose, mannose, salicin, sorbite, glycerine (Andrade indicator) with the formation of acid and no gas, but with subsequent accumulation of alkali.

Traces of acid are noticeable in raffinose, arabinose, isodulcite, erythrite, starch, and lactose. It does not decompose dextrine and lard (Litmus indicator). It reduces nitrates to nitrites with a very intense reaction (Trompfer's reaction).

It grows well on synthetic media of Simons-Drobotko-Dmitrijev-Latschko with the addition of Natr. citricum and produces alkali, but on the addition of Natr. aceticum it does not grow.

It does not agglutinate with the serums of *Bac. enteritidis Gärtneri*, *Bac. paratyphi* Voldagsen, *Bac. typhi abdominalis*.

White mice (2 specimens), dove (1), and rabbit (1) did not react to the introduction of 1 cm^3 of the washings off of one day old agar culture with physiological solution.

In Bergey's «Manual of Determinative Bacteriology» (1934) this bacterium is placed in the family *Bacteriaceae*, subfamily *Bactericae*, and belongs to the genus *Proteus*, notwithstanding its being lophotrichous, its growth on media differing from that of the majority of species of *Proteus*, and its other biochemical pecularities, for in Bergey such *Proteus* are represented by three closely related species.

1) *Proteus noctuorum* White, which causes septicaemia of the cutworm larvae and differs from our bacterium in that it forms a film on bouillon, has only one flagellum, and does not reduce nitrates.

2) *Prot. sphingialis* White, which occurs in the larvae of the hornworm (*Protoparce sexta*, Johan.) and differs from our bacterium by giving a colourless growth on potato, having 1—3 flagella, coagulating milk very slightly and showing certain differences in its growth on coloured media.

3) *Prot. americanus* Pacheco, pathogenic for man, distinguished by the formation of a film on bouillon and by certain peculiarities in the colour series.

The bacterium isolated by M. S. Sturzer and W. S. Vzorov in the larvae of *Euxoa segetum* is also closely related to our bacterium, but, on account of its power of secreting greeny-yellow pigment into the medium, it was referred to the genus *Pseudomonas.*

In view of its specific pathogenic action on adult bees, we propose to name the species under investigation *Proteus apisepticus* and the disease itself septicaemia apis.

We make the conjecture that similar epizoötics among adult bees that were formerly described in the literature had been also due to *Proteus apisepticus.*

In the foreign literature on septicaemia of bees we know only the paper of Dr. C. E. Burnside, who discovered a similar disease in the bee farms of USA in 1927.

The causative agent isolated by Burnside was named *Bacillus apisepticus*, but there is no detailed description of it in the literature available to us. Under experimental conditions, it caused the death of bees only on parenteral infection.

It is absent from the above-mentioned Manual of Determinative Bactereology by Bergey of 1934.

Therefore, the question of the identity of *Proteus apisepticus*, which we have isolated and studied, with Burnside's *Bacillus apisepticus* remains open.

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